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Voice Guidance for Blind People with Ultrasonic Obstacle Avoidance

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Abstract— In order to help the visually challenged people, a study that helps those people to walk more confidently is proposed. The study hypothesizes a smart walking stick that alerts visually-impaired people over obstacles, and fire, water in front could help them in walking with less accident. It outlines a better navigational tool for the visually impaired. It consists of a simple walking stick equipped with sensors to give information about the environment. GPS technology is integrated with pre-programmed locations to determine the optimal route to be taken. The user can choose the location from the set of destinations stored in the memory and will lead in the correct direction of the stick. In this system, ultrasonic sensor, temperature sensor, humidity sensor, GPS receiver, vibrator, voice synthesizer, speaker or headphone, PIC controller and battery are used. The overall aim of the device is to provide a convenient and safe method for the blind to overcome their difficulties in daily life.

Keywords— Blind walking stick, DC motor, Microcontroller, Distance measuring sensor.

Introduction

Visually impaired people are the people who finds it difficult to recognize the smallest detail with healthy eyes. Those who have the visual acuteness of 6/60 or the horizontal range of the visual field with both eyes open have less than or equal to 20 degrees. These people are regarded as blind. A survey by WHO (World Health Organization) carried out in 2011 estimates that in the world, about 1% of the human population is visually impaired (about 70 million people) and amongst them, about 10% are fully blind (about 7 million people) and 90% (about 63 million

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people) with low vision. The main problem with blind people is how to navigate their way to wherever they want to go. Such people need assistance from others with good eyesight. As described by WHO, 10% of the visually impaired have no functional eyesight at all to help themmove around without assistance and safely. This study proposes a new technique for designing a smart stick to help visually impaired people that will provide them navigation. The conventional and archaic navigation aids for persons with visual impairments are the walking cane (also called white cane or stick) and guide dogs which are characterized by a many imperfection. The most critical shortcomings of these aids include: essential skills and training phase, range of motion, and very insignificant information communicated been communicated [1–4]. Our approach modified this cane with some electronics components and sensors, the electronic aiding devices are designed to solve such issues. The ultrasonic sensors, water sensor, buzzer, and RF transmitter/Receiver are used to record information about the presence of obstacles on the road. Ultrasonic sensor have the capacity to detect any obstacle within the distance range of 2cm450cm. Therefore, whenever there is an obstacle in this range it will alert the user. Water sensor is used to detect if there is water in path of the user. Most blind guidance systems use ultrasound because of its immunity to the environmental noise. With the rapid advances of modern technology both in hardware and software it has become easier to provide intelligent navigation system to the visually impaired. Recently, much research effort have been focused on the design of Electronic Travel Aids (ETA) to aid the successful and free navigation of the blind [5–7]. Also, high-end technological solutions have been introduced recently to help blind persons navigate independently. Another reason why ultrasonic is prevalent is that the technology is reasonably cheap. Moreover, ultrasound emitters and detectors are portable components that can be carried without the need for complex circuit. RF module will help the person to find the stick wherever it is placed. Whenever the user wants to locate it, such a person will press a button on remote control and buzzer will ring, then the person can get the idea of where the stick is placed. Vision is the most important part of human physiology as 83% of information human being gets from the environment is via sight. The 2011 statistics by the World Health Organization (WHO) estimates that there are 70 million people in the world living with visual impairment, 7 million of which are blind and 63 million with low vision. The conventional and oldest mobility aids for persons with visual impairments are characterized with

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many limitations. Some inventions also require a separate power supply or navigator which makes the user carry it in a bag every time they travel outdoor [8-11].

This system presents a concept to provide a smart electronic aid for blind people. The system is intended to provide overall measures artificial vision and object detection, real time assistancevia global positioning system (GPS). The aim of the overall system is to provide a low cost and efficient navigation aid for blind which gives a sense of artificial vision by providing information about the environmental scenario of objects around them. In this system embedded system plays a major role. In this system we are using the Ultrasonic sensor, temperature sensor, humidity sensor, GPS receiver, Vibrator, Voice synthesizer, speaker or headphone, microcontroller and Battery. Ultrasonic sensors operate on a similar basis to radar and sonar, evaluating target qualities by interpreting echoes from radio or sound waves, respectively. Ultrasonic sensors generate high-frequency sound waves and measure the echo they receive back. Sensors use the time delay between transmitting the signal and receiving the echo to measure the distance to an object. That signal is transmitted to the embedded systems.

This study aims to develop a tool that can be used to detect obstacles for blind people. This tool also uses the HC-SR04 ultrasonic sensor. The method used in the manufacture of blind assistive prototypes in the form of sticks using Arduino and Ultrasonic Sensors for blind people with the method obtained by hardware design techniques used consists of ATMEGA328 as the main controller, Ultrasonic sensor HS-SRF04 as detecting objects and LM2596 Regulator modules used for lowering the DC voltage level, this study has produced a prototype design stick for blind people using sensor technology to help alert and move blind people who are able to detect objects at a minimum distance of 7 centimeters with output in the form of sound and vibration. The goal of this study is to improve the quality of life for visually impaired people by recovering their capacity to self-navigate. In this paper, we present a small, wearable device that translates optical data into a haptic signal. This device, built solely from commercially available components, allows the user to see distant objects using a distinct sensory modality. Preliminary findings indicate that this gadget is effective for object avoidance in simple situations.

All these sub systems are connected to microcontroller which control the entire operation of the system. This system can be classified as a low cost system. The accuracy of the artificial vision unit provides a high accuracy output for the user. In addition to that, the detection distance of the

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system is 15 meters. However, the designing complexity of the system make it difficult to design and understand. Another study in the same field to help blind people uses the pulse echo technique in order to provide a warning sound when detecting the obstacles. This technique is used by the United States military for locating the submarines. They used pulse of ultrasound range from 21 KHz to 50 KHz which hit the hard surface to generate echo pulses. By calculatingthe difference between signals transmit time and signal receiving time we can predict the distance between the user and the obstacles. This system is very sensitive interms of detecting the obstacles. It has a detection range up to 3 meters and a detection angle between 0 degree to 45 degree. However, this system require more power to operate because of the transmitter and receiver circuits. Another study done by (Sung, Young, Kim and IN, 2001) for developing an intelligent guide stick for blind people used an intelligent CPU called MELDOG which uses artificial intelligence. It can identify the accurate position of obstacles using ultrasonic sensors and laser sensors. In order to identify the position the “map matching technique” was used by using the ultrasonic sensors. This system includes a DC motor controller which connected to the encoder. When the wheels rotate 18 degree the infrared sensors attached to both wheels will transmit the signal to the CPU in order to provide a location update. This system is an accurate detecting system can provide the user continuous update for detecting the obstacles with detection angle between 0 degree to 18 degree. However, this system is expensive and is complex in designing. It is heavy compared to other similar system. The weight of the system is around 5.5 Kg. The detection distance for the system is very low which is around 87.5 cm to 105 cm. a study done by (Jayant, Pratik and Mita, 2012) proposed a smart cane assisted mobility for the visually impaired. The system is based on normal ultrasonic sensors and ATMEL microcontroller. It operates with two rechargeable battery (7.4v) it can be recharged using USB cable or AC adaptor. The control unit is programmed using ATMEL AVR microcontroller ATMEGA328P microcontroller. Once any obstacles are detected vibration and buzzer will start in order to warn the user. This system is a non-complex system to use. It has the ability to cover a distance up to 3 meters and has the rechargeable feature of the buttery. Also, this system can be folded in small piece so that the user can carry it easily. However, this system has only one direction detection coverage and it is inaccurate in detecting the obstacles. All the studies which had been reviewed shows that, there are many types of smart sticks for blind

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people and all of them uses different techniques to give the required assistance for the blind person. However, the studies shows that, using the ultrasonic sensors is an efficient solution to detect the obstacles with maximum range of 7 meters and 45 degree coverage. In addition to that, using a non complex microcontroller will help the blind person to use the devise (stick) easily and without any problems. It is use a 12 volt lithium rechargeable battery. It is low cost and light weight system. An innovative stick is designed for the visually disabled people for their easy navigation.

The blind stick is able to detect the water by integrating with ultrasonic sensor. In this system, the ultrasonic sensors are used to detect obstacles by using ultrasonic waves. By sensing the obstacles the sensor passes the received data to the microcontroller. The microcontroller processes the data and calculates if the obstacle is close enough to the person. If the obstacle is not close to the microcontroller, the circuit does not do anything. If the obstacle is close enough to the microcontroller, it sends a signal to buzzer. The system also detects water and provides different sounds and alerts the blind person.

Literature Survey

The Literature Survey of the research highlights various studies and approaches that have been proposed to aid visually impaired individuals in navigation and obstacle detection. The studies use different technologies such as sensor-based and computer vision, ultrasonic sensors, IR sensors, IoT, and deep learning algorithms to develop assistive devices. These assistive devices aim to improve indoor and outdoor mobility and create a functional system for individuals with visual impairments, including those who are blind. The studies use different feedback mechanisms such as auditory commands, vibrations, and object identification to provide directional information and obstacle detection.

Elmannai W. M., (2018) proposes a data fusion framework for guiding visually impaired individuals. The framework combines data from various sensors such as ultrasonic sensors, depth sensors, and cameras to accurately detect obstacles and provide directional information. The proposed framework also employs machine learning algorithms to enhance the accuracy of obstacle detection and to classify the type of obstacle. The authors conducted experiments to validate the accuracy and reliability of the framework, and the results demonstrate a significant improvement in obstacle detection compared to existing systems. The proposed framework has

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the potential to enhance the mobility of visually impaired individuals and improve their quality of life. Limitations with the above study is: The approach is incapable of showing indoor and outdoor coverage area of obstacles, as well as a directional facility which lacks the ability to recognize longer objects such as doors, walls, and so on.

Somnath and Ravi (2012) developed a voice-activated outdoor navigation system for visually challenged individuals. Uses a stick with ultrasonic sensors and GPS. The stick features GPS and an SD memory card that may be used to store various locations. The user can set the location, and GPS will direct the person to his or her destination. This method will also show the speed and remaining distance to the destination. When the ultrasonic sensors detect an impediment directly, the buzzer activates the vibration motor. This is a low-cost solution that the user can afford. The system makes use of an ARM CPU, which has more memory space and thus a faster operating speed. However, this technique cannot be used indoors due to a lack of GPS signal. The GPS signal's accuracy must be enhanced because it can only be controlled by radios within a 5-meter range. Finally, the blind person must be trained on the system so that they can utilize it successfully. Shruit and Prof. developed a system for employing smart sticks for blind persons that includes obstacle detection, artificial vision, and real-time GPS support. This system works by utilizing GPS, an artificial vision system, and obstacle detection. This system also includes ultrasonic sensors to identify impediments. Once an impediment is recognized or the destination is reached, the speech circuit will activate, giving a specific type of voice.

According to Shah (2006) presents a study on a novel sensory direction model for the visually impaired. The system uses ultrasonic sensors to detect obstacles and direction and transmits this information to the user through vibrations of varying intensity and patterns on a handle. The handle is designed to provide feedback to the user based on the vibration's intensity, sensor position, and signal pulse length. The study involved 15 visually impaired individuals of different age groups who were blindfolded and tested in various navigation scenarios. The device was found to be flexible, lightweight, and ergonomically designed to fit different hand sizes. However, one limitation of this technique is that it cannot be connected to a camera for image processing, which restricts its ability to detect information about crosswalks and traffic signals in the outdoor environment.

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Many electronic devices that aid people with vision loss use information gathered from the environment and provide feedback through touchable or auditory signals. However, the preferred feedback form is still a matter of debate, and opinions vary among individuals. Despite this (Elmannai W. &., 2017), there are certain essential components that any electronic system assisting blind or visually impaired people must have to ensure its reliability and usefulness. These characteristics can be used to evaluate the dependability and effectiveness of the system. However, a drawback of some of these systems is that they may have difficulty detecting objects at certain ranges and are limited to static object detection rather than dynamic object detection. Islam (2019) reviews the development of walking assistants for visually impaired people and discusses recent innovative technologies in this field, along with their merits and demerits. The review aims to draw a schema for upcoming development in the field of sensors, computer vision, and smartphone-based walking assistants. The goal is to provide a basis for different researchers to develop walking assistants that ensure the movability and safety of visually impaired people.

Ponnada (2018) presents a prototype of mobility recognition using feature vector identification and sensor computed processor Arduino chips to assist visually challenged people in recognizing staircases and manholes. The prototype provides more independence to the sightless people while walking on the roads and helps them pass through without any assistance. The model is developed using an Arduino kit and a low-weight stick to recognize obstacles, with the chip programmed and embedded in the stick to detect manholes and staircases using a bivariate Gaussian mixture model and speeded up robust features algorithm for feature extraction.

Proposed Work

Blind stick is an innovative stick designed for visually disabled people for improved navigation. We propose an upgraded blind stick that allows visually impaired people to manoeuvrer with ease utilizing modern technologies. The blind stick includes an ultrasonic sensor as well as light and water detection capabilities. Our proposed technology initially employs ultrasonic sensors to detect impediments ahead using ultrasonic waves. When the sensor detects an obstruction, it sends that information to the microcontroller. The microcontroller then examines this information and determines whether the impediment is close enough.

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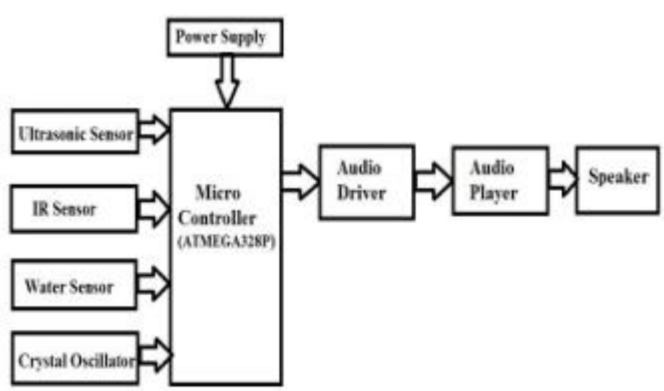
Block Diagram

The microcontroller then processes this data and calculates if the obstacle is close enough. If the obstacle is not that close the circuit does nothing. If the obstacle is close the microcontroller sends a signal to sound a buzzer. It also detects and sounds a different buzzer if it where detects water and alerts the blind.



This system uses ultrasonic sensors to detect obstacles (if any). The sensors are programmed with a threshold limit, and if an impediment is detected within that range, it emits a beep through

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the speaker. To make it easier to recognize obstacles in different directions, several patterns of beep and speech are used (Top, Middle, Pit, and Water). The ultrasonic sensors produce sound scopes with frequencies in the ultrasonic range (>20kHz), which are inaudible to human ears. The sound waves strike the obstruction and ricochet back to the detectors. The ultrasonic sensor detects objects/obstacles in front, while the two infrared sensors detect obstacles on the sides. The signal is subsequently sent to a microcontroller, which operates a buzzer. The microprocessor reads the obstacle's distance using a sensor and controls the buzzer. The buzzer sounds once for a left side obstacle, twice for a front obstacle, and three times for a right obstacle. The vibrator is also linked in parallel to the buzzer to provide vibration sensation. The light sensor provides feedback about the environment. That is, it tells the user whether it is day or night, or whether a specific location is dark or bright. The moisture sensor detects water pitsand puddles. All of these signals are then sent to the microcontroller, which in turn sends a signal to the buzzer, notifying the user.

A. Arduino Uno

Arduino can control the environment by receiving input signals (Digital/Analog) and can effects its surroundings by controlling lights, relays and other devices. The microcontroller on the board is programmed using Arduino software.

B. Ultrasonic Sensor

Generating, detecting & processing ultrasonic signals Ultrasonic is the production of sound waves above the frequency of human hearing and can be used in a variety of applications such as, sonic rulers, proximity detectors, movement detectors, liquid level measurement. Ultrasonic Ranging Module HC - SR04.

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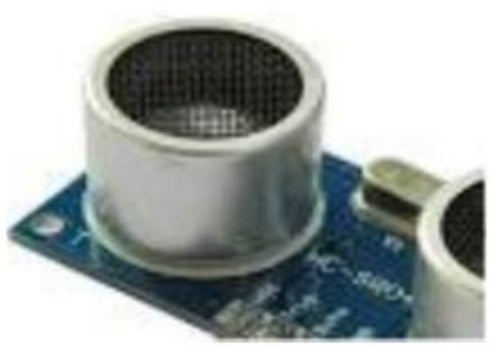
When GSM modem receive a message the microcontroller will process the message with the keyword saved in it. Then, it will get the location of the stick from the GPS modem and transmit the location to the GSM modem in order to respond to the sender. In case of an emergency, the user of the stick can press the emergency button the microcontroller access thelocation from the GPS modem and transmit the location to the GSM modem which will send a SMS messages to the all saved numbers in the microcontroller. location from the GPS modem and transmit the location to the GSM modem which will send a SMS messages to the all saved numbers in the microcontroller.



Ultrasonic transducers are transducers that convert ultrasound waves to electrical signals or vice versa. Those that both transmit and receive may also be called ultrasound transceivers; many ultrasound sensors besides being sensors are indeed transceivers because they can both sense and transmit. These devices work on a principle similar to that of transducers used in radar and sonar systems, which evaluate attributes of a target by interpreting the echoes from radio or sound waves, respectively. Active ultrasonic sensors generate high-frequency sound waves and

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evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions, convert it to an electrical signal, and report it to a computer.

C. IR Sensor

An infrared sensor is an electronic instrument which is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting.

D. Buzzer

A transducer (converts electrical energy into mechanical energy) that typically operates A buzzer is in the lower portion of the audible frequency range of 20 Hz to 20 kHz. This is accomplished by converting an electric, oscillating signal in the audible range, into mechanical energy, in the form of audible waves. Buzzer is used in this research to warn the blind person against obstacle by generating sound proportional to distance from obstacle. VIBRATE MOTOR. A vibrator motor is included to enhance the overall feedback for the person who receives the warning against obstacles closeness in different formats of vibrations.

Working Principle

The main part in the system is the microcontroller that controls the other components in the system. When the ultrasonic sensors detect any objects or obstacle in 180-degree path it will activate the buzzer and the vibration motor. In addition to that, when the GSM modem receive a

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message, it will be sent to the microcontroller which will get the location International Journal of Engineering Science and Computing, August 2018 18789 http://ijesc.org/ of the stick from the GPS modem and transmit the location to the GSM modem in response to the sender. In the areas with low signals cameras can be use, this system works by fitting a camera on the persons head, it will use certain algorithm to identify the highs and obstacles in front the blind person. In case of an emergency, the user of the stick will press the emergency button and the signal from the button will go to the microcontroller which will get the location from the GPS modem and transmit the location to the GSM modem which will send a SMS message to the all saved numbers in the system.

Result and Discussions

ultrasonic sensor position at the front detects strong reflection of waves coming only from the front, meaning that there is an obstacle. The vibrator wrapped around the wrist band vibrate continuously and the recorded voice keep playing "Obstacle on the front" until the user moves away from the obstacle either walking towards left or towards right Similarly if the sonar receives strong ultrasonic waves from the left or right, the system will provide vibration and voice feedback accordingly. Again if the sonar do not receive any reflected wave, then the vibrator and the voice feedback will be inactive, which means the user can walk in any directions

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(right, left and front) unhindered Ultrasonic sensor Fig. 7 An obstacle to the front side is detected and the vibrator vibrates within 70cm range. If the white cane is tilted 45 degree with horizontal axis, then the accuracy of the system will be 95%, with 70 cm as its range. Though the ultrasonic sensor has a 10200cm range, yet for maximum accuracy, 70 cm range was used. As long as the cane is angled at 45 degrees, no matter which way the cane moves, (i.e. left, right or straight) the accuracy will be maximum. Any shift in the angle (300 600) will reduce accuracy to 70-80%.

Conclusion

It is worth mentioning at this point that the aim of this study which is the design and implementation of a smart walking stick for the blind has been fully achieved. The Smart Stick acts as a basic platform for the coming generation of more aiding devices to help the visually impaired to navigate safely both indoor and outdoor. It is effective and affordable. It leads to good results in detecting the obstacles on the path of the user in a range of three meters. This system offers a low-cost, reliable, portable, low power consumption and robust solution for navigation with obvious short response time. Though the system is hard-wired with sensors and other components, it's light in weight. Further aspects of this system can be improved via wireless connectivity between the system components, thus, increasing the range of the ultrasonic sensor and implementing a technology for determining the speed of approaching obstacles. While developing such an empowering solution, visually impaired and blind people in all developing countries were on top of our priorities. The device constructed in this work is only capable of detecting obstacles and moisture. Holes cannot be detected using this device nor the nature of obstacle. Therefore, a better device can be constructed using ultrasonic sensors, arduino Uno and other devices that employ audio commands to alert the user of what is in his path of movement. A vibrator may also be added for ease of use and convenience. In the future, further modifications to enhance the performance of the system will be added. These include: A global positioning method to find the position of' the user using the GPS, and GSM modules to communicate the location to a relative or care giver. It should also accommodate wide varying grips for flexible handling.

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